HISTORY OF THE DISCOVERY OF *SPELEOGNATHUS AUSTRALIS* WOMERSLEY (ACARINA: TROMBIDIFORMES), WITH NOTES ON ITS NATURAL HISTORY AND BEHAVIOUR

by

R. V. SOUTHCOTT

Honorary Research Associate, South Australian Museum, North Terrace, Adelaide, South Australia 5000

(Manuscript accepted 23 January 1985)

ABSTRACT

SOUTHCOTT, R. V. 1986. History of the discovery of *Speleognathus australis* Womersley (Acarina: Trombidiformes), with notes on its natural history and behaviour. *Rec. S. Aust. Mus.* **19**(13): 201-212.

The early history of the discovery of *Speleognathus australis* Womersley, 1936, is recorded. In Australia over 100 specimens of the mite were observed personally on the water surface of three cattle- (and horse-) troughs between 1934 and 1939 at Glen Osmond, South Australia. Despite hundreds of observations in the subsequent years on the fauna of cattle-troughs and other water surfaces, including the original sites at Glen Osmond, and many other sites in Australia and Papua New Guinea, no further specimens of this species have been discovered in Australasia.

This species has been recorded from two other locations as nasal endoparasites of bovids, once being found in the nasal fossae of Zebu cattle, *Bos indicus* L., at Astrida, former Belgian Congo, Africa, and on another occasion in the nasal fossae of the North American bison, *Bison bison athabascae* (Rhodes), near Cache, Oklahoma, United States.

Observations of mite behaviour on the water surface are also described.

INTRODUCTION

Speleognathus australis was described in 1936 by Herbert Womersley (1889-1962), Entomologist, South Australian Museum. In his original account Womersley (1936) gave the following field data:

"Locality.—Type, one of two specimens taken in moss at Glen Osmond, Adelaide, South Australia, in July 1934 (R. V. Southcott); four other specimens from same locality in January 1935 (R.V.S.)."

All of the specimens collected had been caught running over the surface of the water in three (or less) cattle- (and horse-) troughs, at Glen Osmond, South Australia, and this information had been passed on to Womersley. At the time I had been supplying him with large amounts of moss, leaf litter and soil from various localities in South Australia and Victoria, for his studies on the Collembola and Acarina. In view of the volume of this material that Womersley was handling, his initial mistake is understandable. As I was only 16 years old at the time, perhaps understandably he did not check the accuracy of the locality record before publishing.

However, this species of mite was unusual, not only in its morphological similarity to the ereynetid mites (*Riccardoella*) that are common upon slugs in the Adelaide area, but also in its behaviour. Its manner of running on the surface of water showed that it was quite at home there. As far as I was concerned, there was never the slightest question that every specimen found in Australia up to that time (and subsequently) had been collected only upon the water surface of these cattle-troughs. I had found that in collecting mites, Collembola and other anthropods, the surface of each of these cattle-troughs (about 45 cm across by about 150-180 cm long) provided an area for sampling in which all specimens were clearly visible, and at the collector's mercy apart from the occasional water-strider, water beetles, or other truly aquatic insect, and could be captured and bottled in alcohol without difficulty.

On the surface of the water, these light brown Acarina stood out by appearing to be either fully aquatic, or at least adapted to a life at the surface of the water. Specimens were collected from 1934 onwards and taken to Womersley, and repeated observations were made upon their behaviour by myself, both in the field and in the laboratory. These repeated observations were described to Womersley. In fact, on one occasion, I took Womersley, at his own request, to the troughs in question, some time before the publication of his 1936 paper, and possibly as late as April-May 1936, the exact date not being at present available. (Womersley and I lived in adjoining suburbs at the time, and the troughs were within easy walking distance).

It was recognized that the mites' unusual mode of life at the water surface indicated an adaptation to a moist surface, and the possibility of their being nasicolous parasites of cattle and horses was considered. Following the joint inspection, Womersley arranged for the noses of the cattle to be swabbed by a veterinarian on 20 May 1936 (see further later), but no mites were revealed.

When Womersley's paper appeared in 1936, I again advised him that all specimens had been collected at the cattle-troughs and asked him then and on several

later occasions to correct the mistake at some time in the future. This Womersley declined to do.

In 1948 Elizabeth Boyd described a second species of mite in the family Speleognathidae, which Womersley had erected in 1936, and named it *Speleognathus sturni*, since it had been obtained from the nasal passages of starlings (*Sturnus vulgaris* L.) in North America. (A specimen of the mite had also been captured from the boat-tailed grackle, *Cassidix mexicanus*).

In 1952 Lawrence described an intranasal mite from a South African toad, *Bufo regularis*, which he named *Riccardoella eweri* Lawrence, 1952, thus recognizing, as Boyd (1948) had done, the ereynetid affinities of these mites. (This species was later removed to *Lawrencarus* by Fain in 1957, and is now known as *Lawrencarus eweri* (Lawrence, 1952).)

In 1952 also, Crossley described a species of intranasal mite from a small number of specimens obtained from the domestic pigeon, *Columba livia domestica*, in Texas, U.S.A., as *Speleognathus striatus*. That species is at present known as *Ophthalmognathus striatus* (Crossley, 1952) (see Fain 1963, Domrow 1969). Curiously enough, the discussion in Crossley's paper (1952, p. 386) contains the following:

"The type species of the family Speleognathidae, *Speleognathus australis*, was found in moss and has never been reported from a bird. In 1948, Boyd placed in this genus a nasal mite (*S. sturni*) from the starling. The many similarities of the two mites justified this action. Dr Womersley (sic) has suggested (private correspondence) that the type species, *S. australis*, may be a nasal mite and that drinking water may be the vehicle of transmission. The author is in complete agreement. *Speleognathus striatus* has a hydrophobic cuticle, enabling the mite to float on the surface of the water, and also is able to run quite rapidly."

The second Australian species of speleognathid (or speleognathine—the Speleognathidae are now generally considered as only of subfamily status, as Speleognathinae, by recent authors) mite to be discovered was described by Womersley (1953), who erected the genus *Boydaia* for *Speleognathus sturni* Boyd, 1948, and included in this new genus *B. angelae* Womersley 1953, found in "mucus under the tongue of a frog *Limnodynastes tasmaniensis* Gunther var." in Adelaide, by Miss Laura Madeline Angel, M.Sc., of the Zoology Department, University of Adelaide, while she was searching for internal parasites. This species is now placed as *Lawrencarus angelae* (Womersley, 1953) (see Domrow (1961, p. 379)).

Miss Angel has informed me (pers. comm., 1976) that the mite was found stuck in the mucus under the tongue of a frog, in whose oropharynx she was searching for trematode parasites. No mite behaviour was observed. This male frog had come from Meadows, Mt Lofty Ranges, South Australia, in October 1952 (coll. L. M. Angel). The frog was recorded as *L. tasmaniensis* var. *platycephalus*. Miss Angel has commented that she has examined many hundreds of frogs from the Adelaide to lower Murray River regions without finding any other specimens of speleognathine mites. Mr Michael Tyler, Department of Zoology, University of Adelaide, advises (pers. comm., 1976) that the variety *platycephalus* is no longer recognized, and the name of this species of frog remains at *Limnodynastes tasmaniensis* Gunther, 1858.

Womersley also included in his genus *Boydaia* the North American species *Speleognathus striatus* Crossley, 1952.

In his 1953 paper Womersley declared that *S. australis* had been collected by myself "in moss and also on the surface of water in horse troughs at Glen Osmond in 1934 and 1935 . . .

"As all the specimens were females and from the habitat on horse troughs it was thought that in the early stages they may have been parasites in the nasal cavities of birds or cattle drinking at the troughs.

"The swabbing of cattle and the examination of birds, however, failed to show any evidence of this."

A further mite from the Australian speleognathine fauna was described by Womersley in 1954, as *Boydaia derricki* Womersley, 1954. This was collected upon *Rattus assimilis* in Queensland, Australia, and was the first recorded speleognathine mite from a rodent. At the time Womersley believed that the association was "probably accidental". Subsequent work by Fain (1955b), Domrow (1961) and others has shown that several species of speleognathines are parasites of rodents. This species is now known as *Paraspeleognathopsis derricki* (Womersley, 1954) (see Fain 1963). Domrow (1961) has recorded this species in Queensland from *Rattus conatus* and *Rattus rattus*, as well as *Rattus assimilis*. No further reference to *Speleognathus australis* was made by Womersley in that paper (1954), which was his last contribution on the speleognathines.

In 1954 Cooreman recorded a further species of speleognathine mite, *Speleognathopsis galli*, as a new genus and species, from the nasal cavities of the domestic fowl, *Gallus gallus* L., at Astrida, in the then Belgian Congo. In the most recent revisions of the nomenclature (Fain 1963; Domrow 1969), this species remains as *Speleognathopsis galli* Cooreman, 1954.

Fain (1955a) described briefly, in an addendum, a speleognathine mite from Astrida, as *Speleognathus bovis* Fain, obtained from the nasal cavities of "bovidés" (species of cattle were not named). Fain later (1956b) described this species in more detail. Fain (1956a, b) stated that the maxillary and frontal sinuses were the actual sites for the mites. The cattle were still referred to as "bovidés"; recently (1983), in response to the present author's request, Dr Fain has advised that the mites were found in the maxillary and frontal sinuses of Zebu cattle, i.e. of *Bos indicus* L.

Later in 1956 Fain (1956c) was able to state that *S. bovis* was a synonym of *S. australis*, from an examination of authentic material which I collected from Glen Osmond. Moreover, the previous separation was based on inaccuracies in Womersley's descriptions and figures (Womersley's own admission, quoted by Fain (1956b, p. 662)). Fain was also able to include a statement from myself correcting the attribution of the Australian material to moss, and it is also corrected in Southcott's (1957) and Domrow's (1961) papers referring to speleognathine mites.

Drummond and Medley (1964) recorded that on one occasion, in November 1961, near Cache, Oklahoma, two out of three North American bison, *Bison bison athabascae* (Rhodes), examined had an infestation of *Speleognathus australis* in the nasal cavities, with evidence of an abnormal sinus condition, in the form of blackened areas of epithelium, and the sinuses filled with brownish fluid.

Thus the early suggestion that the original speleognathine discovered, *Speleognathus australis*, was an endoparasite upon domestic cattle was substantiated by the observations in central Africa, and in North America.

In subsequent years mites of this subfamily have been recorded from a wide variety of birds and mammals as well as other vertebrates, in several continents. In his review of the Speleognathinae Fain (1963) listed over 40 species, divided among 8 genera and further subgenera (omitting *Lawrencarus* and *Batracarus*, placed by him in the subfamily Lawrencarinae of the Ereynetidae). Since that time further nasicolous ereynetid mites have been described from Australia—see Domrow (1965, 1969, 1975)—and more general reviews have been published by Fain (1969, 1970a, b, 1971a, b), Fain and Aitken (1969), Fain and Hyland (1970, 1975), O'Connor (1978) and Hyland (1979). The nomenclature of these mites at present appears to have reached a degree of stability.

It is an interesting point that had it not been for the fortuitous circumstance that I used cattle-troughs in my area as a means of sampling and collecting small arthropods, *Speleognathus australis* might never have been known to occur in Australia at all. Moreover, had there not been, in Womersley's estimation, an affinity or resemblance to the mesostigmatic mite genus *Spelaeorhynchus* Neumann, 1902, it is safe to say that the history of the nomenclature of this subfamily of mites would have been vastly different.

The literature of these mites is now extensive, but it is not proposed to attempt any general survey here. Instead, the purpose of this paper is to place on record a number of early observations upon the times of occurrence, and certain details of the behaviour of the mite *Speleognathus australis* Womersley, which have either not been recorded at all, or else recorded scantily, and in a somewhat corrupted form in the literature. It is considered that this is justified, since all the Australian observations upon this species have been either in the notebooks or memory of one person, the present author, for 40 years or more. The mites have not been seen in Australia since 1939, and the opportunity of making observations on the species in Africa may well be limited for some time to come.

THE OCCURRENCE OF *SPELEOGNATHUS AUSTRALIS* IN AUSTRALIA

(a) Locality

Over the years 1934 to 1950 (as well as somewhat earlier and later), the area studied at Glen Osmond for *Speleognathus australis* consisted of some open paddocks upon the lower and north-west slopes of Mount Osmond (Fig. 1) at MR656807 to 655806, at a height of 183-191 m (600-625 ft) above mean sea level, on map Adelaide, 1939, No. 810, Zone 6, Sheet 154M/1V SE & SW (Military Survey of Australia, 1:63,360). This area is shown in Fig. 2. The two main paddocks were separated by a stranded wire fence and a roadway (Fig. 3). Both paddocks were used by a Mr Goldsack for agistment of small numbers of domestic cattle (*Bos taurus* L.) (invariably cows, as no bulls or

FIG. 1. General view of Mount Osmond, South Australia, from the north-west, from a photograph taken on 19 August 1938. All of the flatter land around the base of the mountain has been commonly called Glen Osmond. The three cattle troughs upon which all specimens of *Speleognathus australis* have been collected in Australia are at the middle level of the photograph. Trough A is situated somewhat to the right of the centre, in the dark clump of trees. Troughs B and C are further to the right, behind the line of trees.

FIG. 2. Map of the sites of the three cattle troughs at Glen Osmond, South Australia, from which all Australian *Speleognathus australis* Womersley, 1936 have been collected. A, B, C are the sites of troughs A, B, C respectively. The grid squares are 1000 yards square, or 974 m square.

steers were included), perhaps 10 to 20 at the most, and usually many fewer. Horses were also occasionally kept there. Mr Goldsack had no objection to his paddocks and cattle-troughs being used for purposes of biological surveys, as long as there was no interference with or disturbance of stock, and would occasionally ask what was being observed upon the cattle-troughs. The troughs were of the usual galvanized-iron type common in Australia; half-cylindrical, about 45 cm across, and with a float-operated cistern to replenish the water from the suburban reticulated water supply. Of the three troughs studied, one (trough A) (Figs 4 and 5) was actually on the ground surface, being supported against damage from the cattle by being banked up with the clayey soil along the sides. Some grass and weeds at times grew alongside the troughs, but the soil around each of them was largely bare from the continual tread of the cattle and horses. The other two (troughs B and C) (Figs 6 and 7) were close together, to the south-west of trough A, and were placed with the bottom of the trough perhaps 15-30 cm above the soil. Troughs B and C were supported by wooden posts at each end, and trough B also had additional supporting posts at about the middle (see Figs 6 and 7). Although the soil around troughs B and C was as well trodden as that of trough A, some weeds managed to grow underneath them and at the ends where access to the animals was denied. Each of the three tanks had some protective boarding over the cistern, to prevent it being damaged by the cattle. This, to some extent, limited observation of the water surfaces.

FIG. 3. The roadway, fences, and lines of *Eucalyptus cladocalyx* separating the paddock of trough A from that of troughs B and C. Looking southwards from near trough A. Photograph taken in about 1938.

FIG. 4. Trough A and its immediate surroundings, looking up the valley of the centre of the previous photograph (Fig. 3). One cow is present. The trough is on the ground, and is banked up by earth. Photograph taken on 28 January 1938, at about 6 p.m.

FIG. 5. Trough A, looking to the west; with the same cow at the trough as in Fig. 4. The large trees are *Eucalyptus cladocalyx*. Photograph taken 28 January 1938 at about 6 p.m.

FIG. 6. Trough B, looking to the north-east. The trough is in an open paddock. Note the straw on the ground, and many patches of dung. The trees are *Eucalyptus cladocalyx*. Photograph taken 28 January 1938.

Trough A was overhung by a row of sugar gum trees, *Eucalyptus cladocalyx*, which even in the 1930s must have been about 15 m high, and presumably a number of the psyllids and other insects found on the surface came from the foliage of these trees. The other two troughs were also placed about 10 m from a row of *Eucalyptus cladocalyx* bordering the adjacent paddock. All of these trees appeared to be part of one planting, and according to Gill (1905, p. 5), had been planted in 1895.

At times birds were seen to drink at the troughs, and feathers would be found floating in the tanks. There

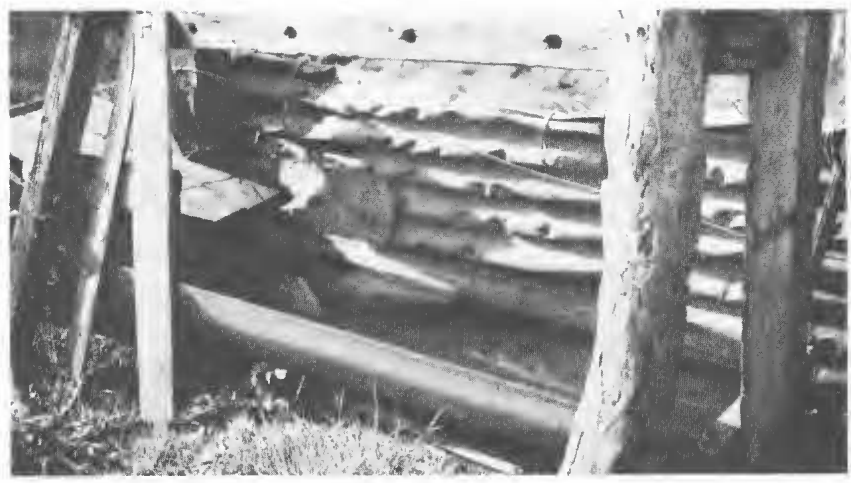

FIG 7. Trough C, near trough B. Photograph taken 12 June 1938.

TABLE 1. NUMBERS OF SPECIMENS OF *SPELEOGNATHUS* OBSERVED* ON THE CATTLE-TROUGHS OVER 1934-1940

	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	Total
Year													
1934	..	..	..	..	..	..	2	0	2	0	0	0	4
1935	—	2	0	0	22	3	2	1	0	0	0	0	30
1936	0	2	6	14	0	0	0	0	0	0	0	1	23
1937	5	3	18	1	1	0	1	1	1	0	0	8	39
1938	1	0	0	0	0	0	0	0	0	0	2	0	3
1939	4	0	1	25	1	0	0	0	0	0	0	3	34
1940	—	—	0	0	0	—	—	—	—	—	0	0	0
Totals	10	7	25	40	24	3	5	2	3	0	2	12	133

— No observation
.. Mites not recorded, presumably not observed
* Not all of these mites were taken. When they were numerous I was careful to take only a representative number, to preserve a presumed breeding population.

appears to be little doubt that these troughs were used freely by the usual range of birds found in suburban Adelaide at the time. The tanks were observed occasionally to have large insects such as small grasshoppers, floating in the water. It was observed also that bees, wasps, and other insects used these troughs for drinking, either directly from the surfaces, or from seepages.

No mammals other than cattle and horses were observed to drink at the troughs, but dogs and cats probably used them occasionally.

Among the local wild mammal fauna were possums (*Trichosurus vulpecula*), bats, rats, and doubtless others; there were no local kangaroos or wallabies. Although a few snakes occurred in the vicinity (the brown snake, *Pseudonaja textilis* (Duméril and Bibron) being occasionally observed), there was no evidence over the years that snakes actually came near the troughs. However frogs undoubtedly used these waters at times.

(b) *Times of Occurrence*

It was my practice for a number of years, to walk each week from my home at Glenunga Avenue, Glenunga, to the Glen Osmond sites for routine collecting. These sites are mentioned in my work (1946) on the Erythracidae, and the location of the three cattle-troughs is close to the "second situation" mentioned in that paper (p. 7). I recorded my findings systematically until 1940, the only exemptions being when I was away on holiday. The numbers of mites observed over the years 1934 to 1940 are shown in Table 1.

Inspection of Table 1 shows that the numbers of mites on the water surfaces of the troughs were maximal in autumn to early winter (March to May), but there was only one month (October) in which no mites were found during the seven-year study.

Over the years I gained the impression that the most likely time to find mites on the surfaces of the troughs was during a spell of fine weather, after rain. It should be remembered that all the observations were made at a time when there was no knowledge of what the host animal's identity might be, or in fact if there were a host species of animal.

BEHAVIOUR OF *SPELEOGNATHUS AUSTRALIS*

I propose to quote in this section a number of the observations recorded in my notebooks, since similar studies have apparently not been made upon this species of mite in its only other known localities and sites of occurrence, in the nasal cavities of cattle in the former Belgian Congo, or of bison on Oklahoma, North America.

28.ii.1936. There were two animals [*Speleognathus australis*] found, one on the surface of water on horsetrough A,

and another on the surface of horsetrough C. [Throughout my notes the term horsetrough is often used, although cattle were by far the major users of these troughs.] The mites seemed to be quite at home on the surface of the water; both were running quickly over it, stopping at times near small objects as though in search for food. The one on horsetrough C mounted the side of the iron trough about 4 cm above the level of the water and then descended. Then it came upon solid material (floating) it ran over it, but only for a few seconds at most.

14.iv.1936. I revisited the horsetroughs. The mites were present in abundance on horsetrough B; none was present on either of horsetroughs A and C. On horsetrough B 13 mites were counted; these were all running quickly over the water surface, apparently either in search of food and/or mates, or suitable places for egg-laying. They were all running fairly quickly, with no noticeable difference in their average speed. All, to the naked eye, were of the same size. One mite was observed to leave the surface of the water, then to mount the sides of the trough to a height of about 3 cm above the water, then to run along the trough for about 20 cm keeping nearly at the same level, then to descend and to run over the water surface once more. I again noticed the preference of the animals for the water surface; most of them did not leave the surface at all except to run over some floating grass etc. This was about 3 o'clock in the afternoon; there were about 10 cattle near the trough. There were no horses, although last Saturday there were about 4 horses there as well as cattle.

The last two or three days have been fine and warm without exception; last Saturday (11.iv.36) was rather cool, and only one mite was found (horsetrough B). This seemed to be in a state of torpor or dead: it was lying on its back on the water.

It appears that a warm spell is necessary to bring the mites out; I have noticed this several times.

Possible conclusions:

1. Mites were all of the same sex.
2. Mites were seeking to lay eggs.
3. From the fact that it has only been found on the water surface of these three troughs it may be that it is parasitic in some stage in cattle, e.g. bronchial passages.

The continued search for clues as to the life history of *Speleognathus australis* led to a number of observations on the minutiae of behaviour. As none of these has been previously recorded, even though the mite has now been described for over 40 years, and as they have not been duplicated in the scanty observations on this species in Africa or North America, it seems worthwhile to publish them.

6.i.1937. One of the three mites taken on 6.i.1937 was kept in a glass jar on [the] surface of water for several days. Various insects were thrown on to the surface but the mite was not seen to feed on any. Piece[s] of grass etc. were placed on the water, and although the mite ran readily over them it always came to rest on the water. It can move its legs about 10-15 times per sec; it would run near the side of the jar and vibrate its legs rapidly without changing its position. The purpose is to me, obscure, for the animal could easily move up the curved surface of the water to the edge.

One other of the three was drowned by immersion for about 1 hour.

13.i.1937. Two were found on trough A. These were quite active. Next day they were put in a tube (without water) [and taken on a journey]. The day was hot. At night they were found to be dead.

27.ii.1937. The speed of the mites on the surface of the water in the troughs was estimated at 1-3 cm/sec.

2.iii.1937. Three were seen on trough A. These attacked a fly (*Musca*) in the water of the trough simultaneously [for] Food? [To lay] Eggs? [It now seems more likely that the fly might have had contact with oro-nasal mucus from the cattle, and thus provided a suitable attractant for the mites.]

26.iii.1937. Two specimens [were] captured running over the surface of trough A. These were placed in a tube, on the surface of some water from [the] trough, together with some of the insects [that had] fallen into the trough, and a specimen of *Cypris* (Crustacea: Ostracoda) from the water. After two days the mites were recorded as dormant, [and] exhibited no signs of life on touching with a needle. [They] remained like this for some time.

The mites remained thus and were almost completely decomposed by 20.v.1937. On 14.viii.1937 the residual scraps of mite skins were removed and slide-mounted.

16.iv.1937. One decomposed mite was found on the trough.

10.vii.1937. Another dead mite was found; first mite found since 16.iv.1937.

16.xii.1937. One mite found on trough A, tipped over on its back. It moved its legs actively when first found, but was feeble a little later. Mite taken.

17.xii.1937. Another mite found and taken, active. It died by 19.xii.1937.

27.xii.1937. Trough A was examined at 4-5 p.m. Three specimens were present. One was dead and decomposed; the other two were active, plump, running actively over the surface of the water. The two came together, circled rapidly, and met (anterior end to anterior end). They were like this for a second or two, moving their legs all the time; then they separated by 2 or 3 mm, and were blown apart by the wind . . .

The trough was re-examined at 8 p.m., when the decomposed mite was as before. One was moving its legs slowly; one was dormant with its legs drawn in under it.

On trough C at 4-5 p.m. there was one very plump and active mite at the surface of the water. At 8 p.m. the (presumably same) mite was floating, tipped over on its back.

On 1.i.1938 I again examined the three troughs at 8 p.m., looking for evidence of possible nocturnal characteristics of the mite. I made the following note:

The evidence of the past few days suggests strongly that the *Spel.* does not leave the water by climbing out [of] the trough—it is possible that it leaves it by means of the cattle drinking there.

On 2.i.1938 the troughs were examined at about 7 p.m. (sunset). On trough A there was one *Speleognathus*, very plump, and running quickly over the water. This I took. Troughs B and C had none. The animal was observed on water in a dish. It moves by moving only the last 3 joints [i.e. segments] of its legs. The tarsus is practically at a right angle to the water surface when at rest, or when moving. It does not move by moving its trochanter on the coxa, but by moving its tarsus and metatarsus [i.e. tibia] backwards and forwards *in a more or less vertical plane*. The animal was drawn in outline, and in its main characteristics, and then killed with Carnoy's fluid. No trace of eggs could be seen in the body. Shape is as figured, widest anteriorly, narrower posteriorly, with sides becoming approximately parallel. (Figure is shown in Fig. 8).

Speleognathus is delicate and cannot withstand much handling or shaking about—either on water or dry.

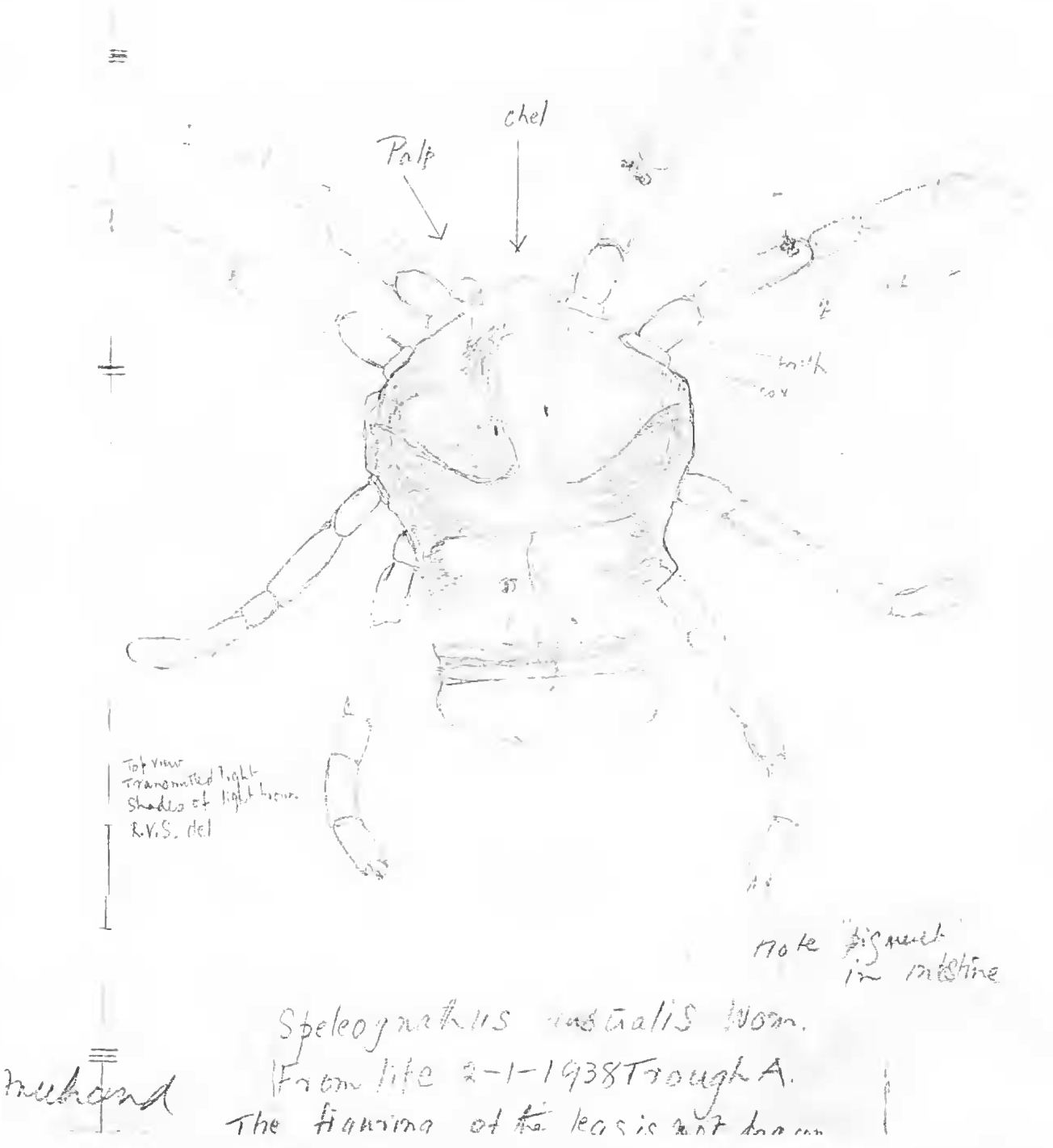

FIG. 8. *Speleognathus australis* Womersley. Living specimen from Glen Osmond, South Australia, 2 January 1938. Drawn freehand through the microscope, on the surface of water. The main lines have been darkened with pencil for reproduction purposes, otherwise the drawing is untouched. The reticular patterning of the legs is omitted.

On 28.i.1938 I photographed troughs A and B (see Figs 4-7) and recorded in my notebooks on that date:

> The cattle are shifted about constantly in the paddocks containing troughs A, B and C, but rarely are any of the paddocks containing the troughs without cattle for more than a few days.

A few further observations were made during 1939 and 1940, but I find from my notebooks that all records for 1940 were negative, and the last living mites seen by me were collected in December 1939. (Previous statements implying that the mites were seen as late as 1941 were based on faulty recollection.)

On 29.i.1939 I observed four mites on trough A, but none on B or C. One of the four was alive; three were dead (one apparently not long dead, one with legs flexed under it, and one decomposed). I made the following comments in my notebooks:

> Conclusions: The hot spell has brought out *Speleognathus*, following as it does fairly wet weather . . . *Note*: Dead Speleognathi are found *on the water.*
>
> I observed the living *Speleognathus* for about half an hour [on the trough]. When the . . . (just dead) *Speleognathus* was put in its way it ran over it without

stopping. The animal seems to give no preference to light or shade. Ran for a length of a metre (with frequent stoppings, and many turns, and doublings back, and assisted by the wind, and water currents. Stops varied from 0-10 seconds, rarely the latter, usually about 3 seconds.

It was put near the edge of the trough, but did not go up at all. Also, it took no notice of algae just below the surface of the water.

Wasps, bees [are] observed drinking here. Cows drink here, and dogs sometimes; and birds (magpies) [This means the white-backed magpie of south-eastern Australia, *Gymnorhina hypoleuca* Gould. These frequently nest in tall trees, such as the rows of planted *Eucalyptus cladocalyx* bordering the paddocks containing the troughs.] live here), and some bird feathers [were] seen in [the] trough. Many ants [are] about; some fall in the water. One butterfly *(Danaus archippus)* [Now *Danaus plexippus plexippus* (L., 1758) (see Common and Waterhouse, 1972, p. 221)] [was] seen drinking.

Troughs B and C were swarming with *Cypris*. Troughs A, B and C were swarming with nematidiform (almost) larvae. Small bugs run over the surface of the water. Water dirty, much alga present.

A sketch was made of the path of the *Speleognathus* on the water, over a small area, to indicate its many twists and turns. This is reproduced in Fig. 9.

FIG. 9. Drawing made on 19 January 1939, of the path of a specimen of *Speleognathus australis* on a limited area of the water surface of trough A at Glen Osmond, South Australia, reproduced at original size. The wind direction, and water current directions are shown. It is apparent from this sketch that the mite was not under the control of either the wind or water currents, and could move at will upon the water.

On 9.iv.1939 I observed 25 of these mites upon the surface of trough B; there were none on troughs A and C.

> All of these were dormant with the legs *strongly flexed*. Not one was seen to be in a state of decomposition. Not one was seen to give any movement at all, although several were stimulated by touching and several were taken (7 in all)—5 were taken as they were, 2 others put in alcohol—not seen to move at all). The mites were in any position e.g. tilted on their posterior ends, their sides, or in normal position. None was on its back. The occurrence is most remarkable . . . the only sunny day recently is today . . . no cattle were drinking at the troughs, or present in the paddocks . . . on 9.iv.1939. The five unpreserved mites were examined 6 hours later, but were unchanged, and were then preserved for histological study.

Observations continued, but did not throw any further light on the presumed host animals or life-history of these mites.

By 1940 I was systematically noting the various species of birds seen in the vicinity of the troughs, but without drawing any significant conclusions.

During 1941 I was able to make only a few observations, and thereafter, owing to military duties, I was not able to inspect the area again until 1946. By then troughs A and B had been removed. Trough C remained and was examined at irregular intervals from 1946 to 1949, and occasionally later, to 1953, but no further *Speleognathus* was found.

POSSIBLE HOSTS OF SPELEOGNATHUS AUSTRALIS

The possibility that these mites were endoparasites of the nasal or other respiratory passages of mammals and birds drinking at the troughs was entertained quite early. Since the only residual local marsupials were arboreal ones, such as *Trichosurus vulpecula* and smaller species, it did not seem likely that marsupials would prove to be the hosts. The animals drinking most commonly at the troughs were cattle, with a smaller population of horses, but it would seem likely, *prima facie*, that if such mites were parasites of the nasal spaces of cattle and horses, they could hardly fail to have been detected in Europe, the obvious source of the Australian domestic breeds of cattle and horses; not to mention the other domestic animals in South Australia, such as dogs, cats, and so on. Similar considerations applied to introduced rodents. Bats appeared to be another possibility, but rather a remote one, although insectivorous bats were not uncommon in the neighbourhood, even if mainly crepuscular or nocturnal.

Other possibilities that were considered, either then or later, were that the mites could be tracheal parasites of water insects occasionally seen upon the troughs. Conceivably also small gastropods might serve as hosts, in the same way as *Riccardoella* utilizes the common introduced slugs in South Australia, because of the obvious resemblance between *Speleognathus* and *Riccardoella*. However, no solid evidence was found to support seriously any suggestions of a non-vertebrate host.

Since the mites were reasonably common at times, and since the cattle were the commonest large mammal utilizing the troughs, it seemed worthwhile to investigate further the possible role of the cattle.

My notebooks record:

> 20.v.1936. Cattle drinking at troughs A, B and C at Glen Osmond, South Australia, had their nostrils swabbed. No *Speleog.* were obtained.
>
> This is not surprising, and probably the result does not mean very much, since more than a month had passed since any of these mites had been seen on the troughs. (Tests performed by C.S.I.R. officers, at suggestion of H. Womersley (to them, that is).)

I was not a witness to the event, the information having come from Womersley (1953, p. 82) who referred to it briefly.

After this negative result, no further attempt was made to locate the mites in the nostrils of the cattle. Subsequently the possible relationships remained matters of speculation, as the various new species of speleognathines were discovered in North America, Africa, and other continents. The next species to be discovered was by Elizabeth Boyd (1948), in North American birds.

At the end of 1938, under the existing means of study, I had summarized the possibilities of host-relationships in my notebooks as follows:

> (a) Nature of the appearances of the animal on the water surface
>
> 1. This cannot be fortuitous—from ease of its progression;
> 2. There are no streams left in this locality—even in winter they do not run (although they do contain water for a while)—and only remain with water in them for a short time. The troughs are from 10-25 m from the creek bed.
>
> (b) Fauna which might be related
>
> (1) Non-aquatic
> Birds (the word *especially* added in pencil at some later date, and the word *birds* underlined)) drink here
> Cattle)
> Insects including wasps, bees, bugs, etc
> (2) Aquatic)
> Trough contains a rich fauna of *Cypris*. In Dec. 1938 many nematodes (?) were present. (There is a good collection of filamentous algae in each trough) . . .
>
> (c) Flora which might be related
>
> (1) Non-aquatic—eucalypts, grass, weeds
> (2) Aquatic—green algae mainly ?*Spirogyra*
>
> Addendum 1.i.1939
>
> Only 3 *Speleog.* [were] seen in 1938 (and caught). (cp. 1935 with 26, 1936 with 23, 1937 with 34 (approx. figs.).
> It may be that the continual taking of the *Spel.* has reduced their number considerably.

That surmise was contradicted by the finding of a large number in 1939; in fact the count of 25 for March 1939 was the highest for any individual month over the whole period of the observation.

OTHER ATTEMPTS TO FIND *SPELEOGNATHUS* IN AUSTRALIA AND PAPUA-NEW GUINEA

Over the last 40 years I have looked systematically for *Speleognathus australis* (and related mites) when travelling in Australia and Papua-New Guinea. No cattle-trough encountered which contained water was ever left uninspected. Despite searches in Papua-New Guinea (two sojourns) and in every Australian state except Western Australia, none has been found. Additionally, a search has been made for intranasal mites in birds and other vertebrates from 1942 onwards, as opportunity permitted, but again all examinations failed to reveal any speleognathine mites.

After the discovery of *S. sturni* by Elizabeth Boyd (1948) in North America, I decided to make more systematic and frequent efforts to find these mites at bird drinking sites. I erected two troughs at my then home at Unley Park, a southern suburb of Adelaide, by cutting a 44-gallon drum in halves longitudinally. One (D) was erected about a metre above ground level, on the stump of a cypress tree, and the other (E) was erected on a wooden frame about two-thirds of a metre above ground level amidst trees, bushes and other vegetation. Birds were encouraged by suitable feeding to drink at the troughs. Trough D was observed regularly for nearly 4 years, and trough E for over 3 years. Observations were made daily, at times oftener, over much of this period. Despite these efforts, however, no speleognathines were found.

During 1952 and 1953 I carried out systematic observations of the horse-troughs still located around the streets, parks and other open spaces around Adelaide. Thus 40 observations were made in March-June, 1953, and observations continued into 1954, when they were abandoned. Again, no speleognathines were found.

DISCUSSION

It may reasonably be concluded from these many hundreds of observations that *Speleognathus australis* must be an uncommon species in Australia. If it were a common parasite of cattle, it is reasonable to believe that it would occasionally come to the notice of veterinarians. There is, of course, no evidence at present that this species of mite is concerned with disease transmission in any way, or in fact that it causes serious harm to its hosts. Nevertheless, the lesions recorded briefly in one specimen of North American bison by Drummond and Medley (1964) show that this species of mite is capable of causing some tissue damage. Presumably the mechanism is similar to that in, for example, *Riccardoella limacum* (Schrank) (Ereynetidae) which feeds on slugs and is capable of killing them under laboratory conditions of heavy infestations (Baker 1970a, b). Baker (1971) studied the ereynetid mite *Xenoparcarus africanus* Fain, Baker and Tinsley, 1969, which lives in the nasal passages of the African clawed toad *Xenopus laevis* Daudin, and demonstrated blood in the gut by histochemical tests. Both of these species of mites have mouthparts which appear capable of penetrating epithelium.

Baker (1973) discussed this further and commented (p. 51): "The feeding of ereynetid mites, involving the production of a stylostome, appears to be basically similar to that already described in such trombiculid mites as *Neotrombicula zachvatkini* Schluger and *Trombicula autumnalis* Shaw . . . ".

Other groups of invertebrates have exploited the same niches, such as various mesostigmatid mites, and the family Trombiculidae (*sensu lato*) of the Trombidiformes.

The second major question which a student of the distribution of *Speleognathus australis* will ask, is how can we explain the greatly separated distribution of the species, known only from three recorded localities: Glen Osmond in South Australia, Astrida in the former Belgian Congo, and Oklahoma in North America. In the African and North American cases there was evidence of nasal parasitization of a bovid, while in the Australian case there was evidence pointing to an association with cattle. Only one species is now classified in the genus *Speleognathus*; all other speleognathines, from a wide variety of vertebrate hosts, are now placed in other genera (Fain 1963).

We may reasonably accept that *Speleognathus australis* is a bovid-adapted nasicolous species.

The problem remains, however, of its extremely disjunct distribution as at present known. Although I stated (1963, p. 328) that this was "easily explicable since a number of the original cattle of Australia were of African origin", it now seems that that explanation was too facile, particularly in view of the finding of *Speleognathus australis* in North America. In any case the proposal did not explain the lack of reports of the mite in southern Africa, nor from New South Wales and other parts of Australia.

At this point we have to leave the study of its biology and distribution with much of the mite's natural history in Australia at last accurately recorded in some detail but with some major ecological questions still unanswered.

REFERENCES

BAKER, R. A. 1970a. Studies on the life history of *Riccardoella limacum* (Schrank) (Acari-Trombidiformes) *J. nat. Hist.* **4**: 511-519.

BAKER, R. A. 1970b. The food of *Riccardoella limacum* (Schrank) -Acari-Trombidiformes and its relationship with pulmonate molluscs. *J. nat. Hist.* **4**: 521-530.

BAKER, R. A. 1971. Observations on aspects of nutrition in *Xenopacarus africanus* (Ereynetidae: Trombidiformes). *J. med. Entomol.* **8**: 307-313.

BAKER, R. A. 1973. Notes on the internal anatomy, the food requirements and development in the family Ereynetidae (Trombidiformes). *Acarologia* **15**: 43-52.

BOYD, Elizabeth, M. 1948. A new mite from the respiratory tract of the starling (Acarina, Speleognathidae). *Proc. Ent. Soc. Washington* **50**: 9-14.

COMMON, I. F. B., and WATERHOUSE, D. F. 1972. "Butterflies of Australia". Angus and Robertson, Sydney.

COOREMAN, J. 1954. Sur un acarien nouveau, parasite des fosses nasales des oiseaux et remarques sur la famille des Speleognathidae. *Ann. Parasitol. hum. comp.* **29**: 426-432.

CROSSLEY, D. A., Jr. 1952. Two new nasal mites from columbiform birds. *J. Parasitol.* **38**: 385-390.

DOMROW, R. 1961. The family Speleognathidae in Australia (Acarina). *Proc. Linn. Soc. N.S.W.* **85**: 374-381.

DOMROW, R. 1965. Three speleognathid mites from Australian birds. *Acarologia* **7**: 43-48.

DOMROW, R. 1969. The nasal mites of Queensland birds (Acari: Dermanyssidae, Ereynetidae, and Epidermoptidae). *Proc. Linn. Soc. N.S.W.* **93**: 297-426.

DOMROW, R. 1975. A new species of *Paraspeleognathopsis* Fain (Acari: Ereynetidae) from an Australian dasyurid marsupial. *J. Aust. Ent. Soc.* **14**: 97-99.

DRUMMOND, R. O., and MEDLEY, J. G. 1964. Occurrence of *Speleognathus australis* Womersley (Acarina: Speleognathidae) in the nasal passages of bison. *J. Parasitol.* **50**: 655.

FAIN, A. 1955a. Sur un nouvel acarien parasite des fosses nasales de la perdrix au Ruana-Urundi: *Boydaia pterastris* n. sp. (Speleognathidae). *Rev. Zool. Bot. afr.* **52**: 144-149.

FAIN, A. 1955b. Sur le parasitisme des fosses nasales chez les mammifères et les oiseaux par les acariens de la famille Speleognathidae (Acarina). Description d'une espèce nouvelle chez les chauve-souris. *Ann. Soc. Belg. Méd. Trop.* **35**: 689-700.

FAIN, A. 1956a. Les acariens de la famille Speleognathidae Womersley au Ruanda-Urandi (Congo Belge). *Rev. Zool. Bot. afr.* **53**: 17-50.

FAIN, A. 1956b. Présence d'acariens de la famille Speleognathidae Womersley dans les fosses nasales de mammifères. Description de trois espèces nouvelles. *Ann. Parasitol. hum. comp.* **30**: 155-168.

FAIN, A. 1956c. Nouvelles observations sur les acariens de la famille Speleognathidae parasites des fosses nasales chez les batraciens, les oiseaux et les mammifères. *Ann. Parasitol. hum. comp.* **31**: 643-662.

FAIN, A. 1957. Sur la position systématique de *Riccardoella eweri* Lawrence 1952 et de *Boydaia angelae* Womersley 1953, Remaniement de la famille Ereynetidae Oudemans 1931. *Rev. Zool. Bot. afr.* **53**: 249-252.

FAIN, A. 1963. Chaetotaxie et classification des Speleognathinae (Acarina: Trombidiformes). *Bull. Inst. Roy. Sci. Nat. Belg.* **39**: 1-80.

FAIN, A. 1969. Nouvelles Speleognathinae parasites nasicoles d'oiseaux (Acarina: Trombidiformes). *Rev. Zool. Bot. afr.* **80**: 369-376.

FAIN, A. 1970a. Nomenclature des poils idiosomaux et description de trois espèces nouvelles dans la famille Ereynetidae (Trombidiformes). *Acarologia* **12**: 313-325.

FAIN, A. 1970b. Acariens nasicoles d'oiseaux et de mammifères de Brésil. IV. Nouveaux Ereynetidae (Trombidiformes) et Turbinoptidae (Sarcoptiformes) de la région de Belem (Nord Brésil). *Acarologia* **12**: 326-338.

FAIN, A. 1971a. Notes sur les spéléognathines parasites nasicoles des mammifères (Ereynetidae: Trombidiformes). *Acarologia* **12**: 509-521.

FAIN, A. 1971b. Clé et liste des espèces du genre *Boydaia* Womersley (Ereynetidae: Trombidiformes). *Acarologia* **13**: 98-112.

FAIN, A., and AITKEN, T. H. G. 1969. Acariens nasicoles d'oiseaux et des mammifères du Brésil. II. Ereynetidae de la région de Belem (Nord Brésil). *Bull. Ann. Soc. Roy. Entom. Belg.* **105**: 33-44.

FAIN, A., and HYLAND, K. E. 1970. Acariens nasicoles des oiseaux du Mexique. III. Familles Ereynetidae et Turbinoptidae. *Bull. Ann. Soc. Roy. Entom. Belg.* **106**: 37-46.

FAIN, A., and HYLAND, K. E. 1975. Speleognathinae collected from birds in North America (Acarina: Ereynetidae). *J. New York Ent. Soc.* **83**: 203-208.

GILL, T. 1905. "The History and Topography of Glen Osmond". Vardon and Pritchard, Adelaide.

HYLAND, K. E. 1979. Specificity and parallel host-parasite evolution in the Turbinoptidae, Cytoditidae and Ereynetidae living in the respiratory passages of birds. *In* "Recent Advances in Acarology", Vol. II (J. G. Rodriguez, ed.), pp. 363-369. Academic Press, New York.

LAWRENCE, R. F. 1952. A new parasitic mite from the nasal cavities of the South African toad, *Bufo regularis* Reuss. *Proc. Zool. Soc. London* **121**: 747-752.

O'CONNOR, B. M. 1978. A redescription of *Speleorodens michigensis* (Ford) n. comb. (Acari: Ereynetidae), a nasal mite

of microtine rodents, with comments on generic relationships in the Speleognathinae. *J. New York Ent. Soc.* **86**: 123-129.

SOUTHCOTT, R. V. 1946. Studies on Australian Erythraeidae (Acarina). *Proc. Linn. Soc. N.S.W.* **71**: 6-48.

SOUTHCOTT, R. V. 1957. Description of a new Australian raphignathoid mite, with remarks on the classification of the Trombidiformes (Acarina). *Proc. Linn. Soc. N.S.W.* **81**: 306-312.

SOUTHCOTT, R. V. 1963. Obituary notice, Herbert Womersley (1889-1962). *Acarologia* **5**: 323-334.

WOMERSLEY, H. 1936. On a new family of Acarina, with description of a new genus and species. *Ann. Mag. nat. Hist.* (10) **18**: 312-315.

WOMERSLEY, H. 1953. A new genus and species of Speleognathidae (Acarina) from South Australia. *Trans. R. Soc. S. Aust.* **76**: 82-84.

WOMERSLEY, H. 1954. Another new species of *Boydaia* (Speleognathidae: Acarina) from Australia. *Trans. R. Soc. S. Aust.* **77**: 65-66.